RESEARCH HIGHLIGHT

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LABORATORY DEPRESSURIZATION TEST FOR RESIDENTIAL GAS APPLIANCES

INTRODUCTION

CMHC partnered with NRCan to undertake this project to develop a depressurization spillage test protocol. The project evaluated the performance of a sample of residential combustion appliances using the new test.

Spillage from combustion appliances is a complex problem to solve. The frequency and severity of combustion spillage is affected by the installation of the equipment and the use of other air exhausting equipment installed in the home which can over-power the appliance venting system. Existing Canadian codes and standards have attempted to deal with combustion spillage by such strategies as requiring make-up air supplies for installations that may not have sufficient air leakage to support the proper operation of the combustion appliances.

Manufacturers have also developed appliances that are more spillage-resistant. Generally, they have either been designed in such a way that their combustion and venting components should not be exposed to the pressure regime inside the house, or they have been equipped with strong power venting systems that should be able to operate even when depressurized conditions exist. The first type of product are often referred to as direct-vent or isolated combustion appliances. They are usually vented using side-wall mounted terminals rather than through a chimney. Power vented water heater tanks are one of the more familiar examples of the second type of appliance designed for improved resistance to combustion spillage.

Despite the widespread availability of appliances that have been designed to have greater resistance to depressurization spillage, no standard protocol exists that would allow a manufacturer to directly test and rate their products for combustion spillage resistance. This means that manufacturers have no accepted way to notify consumers, builders or other stakeholders of the rated spillage resistance of their appliances, or to indicate which of their products perform better under reduced pressure conditions that might cause spillage in other products.

The new depressurization spillage test has been developed as a key instrument towards addressing this gap. This research project focussed on the performance of contemporary appliances. It did not investigate the depressurization spillage resistance of older designs of combustion appliances that may still be installed in Canadian houses.

RESEARCH PROGRAM

The research program was conducted between January 2005 and May 2005. Testing was done at Bodycote, a Canadian commercial testing laboratory.

Seven combustion appliances (two water heaters, three furnaces and two fireplaces) were chosen to cover a cross-section of the types of gas-fired equipment that are now being installed in Canadian homes. The appliances and their venting systems were purchased from regular HVAC distributors, not directly from manufacturers. They were shipped directly to the testing laboratory by the distributors. Each was installed and tested, following the manufacturer's certified installation instructions and using the maximum equivalent length and type of venting materials specified by the manufacturer.

The new test incorporates a "pass" threshold of 2 per cent spillage. This figure was chosen to give some flexibility in the choice of test instrumentation and it provides a small margin for errors associated with cumulative uncertainties in the testing procedure and the required measurements. This is the same tolerance that is used in static leakage tests for combustion vent sections of sealed-combustion appliances that operate with positive vent pressures. Such appliances already require vent leakage tests according to existing appliance certification standards (for example CSA 4.3, CSA 4.9, CSA B140.0). However, it must be understood that static leakage tests are performed at different pressures and they are performed with the appliances and their vent systems at ambient temperature, and not operating.

Acceptance of the 2 per cent "pass" tolerance for the spillage test should not be construed as a judgment that 2 per cent combustion spillage would be acceptable performance for combustion appliances. Indeed, 2 per cent spillage from certain types of combustion appliances may not be acceptable for all installations.

THE SPILLAGE TEST

The depressurization spillage test is briefly described below.

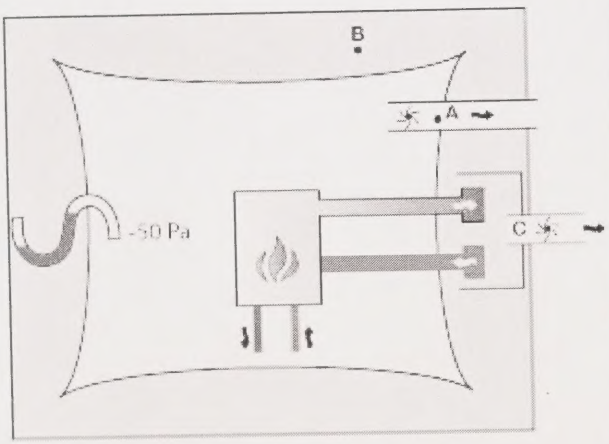

Figure 1: Simplified Concept of the Depressurization Spillage Test

In Figure 1, the box with a flame represents the combustion appliance installed inside the depressurized test room. The horizontal ducts (with white arrows) attached to the appliance represent the combustion air inlet and the combustion vent. The appliance is shown drawing its combustion air from outside the test room and exhausting its combustion products outside the test room. Some appliances draw their combustion air from inside the test room. The vertical lines represent the thermal load and output from the appliance that may either be released inside the test room or rejected outside the room (rejection is simpler for products that heat water such as water heaters and boilers).

The test room is depressurized (by 50 Pa in the illustration) with respect to its surroundings using a variable fan installed in duct "A" that discharges outside the building. A supplemental exhaust system "C" captures and removes the combustion products to avoid contaminating the area "B" around the test room.

The appliance is operated to obtain a five minute period of burner operation. The amount of CO_2 that was released or "spilled" into the test room is determined over the five minute period and an additional two minutes (to include any spillage of combustion gases from the venting system after the burner shuts down). The amount of CO_2 that was spilled into the test room is divided by the amount of CO_2 that was produced by the burner during the test to calculate the percentage of combustion spillage.

For each unit, the test was initially performed with the test room depressurized by 50 Pa compared with the pressure outside the room. If the combustion spillage exceeded 2 per cent, the test was repeated with the room depressurized by 20 Pa. Finally, if the measured spillage exceeded 2 per cent at 20 Pa, a test was performed with the room depressurized by 5 Pa.

RESEARCH FINDINGS

The spillage test was relatively easy to perform. Of the seven gas-fired appliances tested at 50 Pa depressurization: three had no detectable spillage; three had minor, but measurable spillage; one had significant spillage. The test results are summarized in Table 1.

	Power Vented Water Heater Tanks		Non Condensing Furnace	Condensing Furnaces		Direct Vent Fireplace Insert	Direct Vent Zero Clearance Fireplace
	A	B	C	D	E	F	G
Maximum Rated Input kW (Btu/h*1000)	10.5 (36)	10 (34)	22 (75)	23 (80)	23 (80)	7 (24)	6 (21)
Maximum Rated Combustion Vent Length - m (ft)	18 (60)	15 (50)	11 (35)	18 (60)	17 (55)	11 (35)	4 (12)
Maximum Rated Intake-Air Length - m (ft)	N/A	N/A	N/A	18 (60)	17 (55)	11 (35)	4 (12)
Burner Pre-Purge Time (s)	15	15	15	60	45	0	0
Burner Post-Purge Time (s)	30	30	15	30	15	0	0
Depressurization Spillage (%)							
50 Pa	1.1	1.55	0.2	0.04	0.14	13	0.7
20 Pa	-	-	-	-	-	3.5	-
5 Pa	-	-	-	-	-	0.0	-

Table 1: Research Results

Based on these test results, it is evident that many existing products are capable of performing well when depressurized. At the same time, other products that appear similar do not perform so well. The new test can reliably identify those products that perform well.

Because of the 2 per cent spillage tolerance, this test may have difficulty in conclusively differentiating between a close "pass" and a marginal "fail". If such a spillage result were obtained, further investigations and repeat tests would likely be warranted before reaching a conclusion. In this project, the closest result to the spillage threshold was 1.55 per cent for one product. While higher than ideal, that test result was more than 20 per cent below the proposed limit. The result was considered to be a "pass".

IMPLICATIONS FOR THE INDUSTRY AND OTHER STAKEHOLDERS

The facility and instrumentation requirements for the depressurization spillage test are low enough that manufacturers should have little or no difficulty in setting up the test in their own facilities and using it as a product development tool. This will enable them to verify the performance and improve the spillage resistance of their products.

The spillage test is a new tool that allows manufacturers to include depressurization spillage resistance ratings in their literature alongside their other product performance data. It is anticipated that the spillage test will be immediately useful to manufacturers who want to emphasize the performance of their products in depressurized environments, such as in houses with large exhaust appliances.

REFERENCES

"Depressurization Spillage Test Final Report," Prepared by Peter Edwards Co. for CMHC and NRCan, July 2005.

"Laboratory Evaluation to Assess a Proposed Test Method to Determine Transient Combustion Spillage," Prepared by Bodycote Materials Testing Canada Inc for NRCan, July 2005

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Housing Research at CMHC

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